Development of a plate discrete element method: geometry and kinematics

[*,†]Jian Chen[1] and Hans-Georg Matuttis[2]

[1]Center for Mathematical Science and Advanced Technology,
Japan Agency for Marine-Earth Science and Technology.
[2]Department of Mechanical and Intelligent Systems Engineering,
Graduate School of Informatics and Engineering,
The University of Electro-Communications.

[*]Presenting author: jchen@jamstec.go.jp
[†]Corresponding author: jchen@jamstec.go.jp

Abstract

The discrete element method (DEM) [1] is widely recognized as a powerful tool for investigating the complex dynamics of granular materials [2]. Most DEM simulations are built on round particles, which deviate from actual particle shapes in reality. The particle shapes at microscopic scale play an important role in the macroscopic response of the granular assemblies [3]. There are granular particles with platelike geometry where the thickness dimension is negligible. A prominent example is clayey particles in nature, which have novel potential applications such as prohibiting cancer cells [4]. Such types of granular materials have a very large surface to volume ratio which is difficult to model by spheres or cluster of spheres. Though polyhedral DEM is available, the overlap geometry computation would suffer numerical difficulties due to the vanishing of thickness dimension. Thus, it is worthy developing a new plate DEM for granular materials such as clayey particles. As a first step, in this paper, we put forward the formulations for the kinematics of plate DEM using unit quaternions for the description of the angular degree of freedom. In addition, the angular motion is solved in a body-fixed rather than a space-fixed reference frame. As a demonstration, we demonstrate the simulation of the rotation of a collection of plate particles under the conservation of angular momentum without external torque.

Keywords: plate DEM; clayey particle; unit quaternions

References

[1] Cundall, P., Strack, O. (1979) A Discrete Numerical Model for Granular Assemblies. *Geotechnique **29***, 47–65.
[2] Chen, J., Kitamura, K., Barbieri, E., Nishiura, D. and Furuichi, M. (2022) Analyzing effects of microscopic material parameters on macroscopic mechanical responses in underwater mixing using discrete element method, *Powder Technology* **401**, 117304.
[3] Matuttis, H.-G. and Chen, J. (2014) *Understanding the Discrete Element Method: Simulation of Non-Spherical Particles for Granular and Multi-body system*, Wiley.
[4] Abduljauwad, S.N., Ahmed, HuR. (2019) Enhancing cancer cell adhesion with clay nanoparticles for countering metastasis. *Sci Rep* **9,** 5935.